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Does 'Land Release' process in Humanitarian Demining Promote Sustainable Land Management? A Review of Literature

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Abstract
The availability of land is a sine qua non for the livelihood of people and communities. Land availability is invariably and substantially reduced in the regions aftermath of the war and or civil conflict owing to damage caused to the land by environmentally destructive landmines. The "Land Release" process of demining has thus become a significant humanitarian and sociological endeavour in order to restore land for productive use through the removal and destruction of all forms of dangerous battlefield debris, in particular through the removal of landmines and other explosive remnants of war (ERW) are vital prerequisites for any region in order to restore the land from calamitous status.

In demining terminology, the purpose of land release is to identify, define and remove all presence or suspicion of mines and other ERW. The purpose of this paper is to examine the land release process in humanitarian demining in general, and to find out whether it promotes sustainable land management. When doing a detailed content analysis, it seems that most of the research work so far has been empirical. This paper will focus on existing publications from mine action organizations working with research and publications, mine action authorities and other referred journals using the systematic literature review (SLR) method. The study shows that approaches based on International Mine Action

Standards (IMAS) enrich the land release mechanism leading to sustainable land management. The findings also suggest that incorporating mine awareness and risk education in land release operations will have an added advantage in achieving sustainable land management.

Keywords*:* Sustainability, Explosive Remnants of War, Humanitarian, Demining, Land Release

Introduction

Sustainable land management in general implies proper utilization of land while caring for natural resources in ways that ensure ecological and socio-economic benefits for present and future generations. Land is a finite declining resource. It is subject to challenging pressures from urbanization, infrastructure development, increased food fuel and fiber production as well as the provision of key ecosystem services. Land-based capitals are a crucial asset to people in developing countries, whose income and subsistence of goods are depended on such resources. The uses of these resources are extensive and adaptable to various circumstances, often serving as a means of security against adverse shocks or as a resource that can facilitate access to new possibilities. Land being an important resource threatened many a dwindling factor, it has to be utilized while ensuring its sustainability. This is what is known as sustainable land management by United Nations Earth Summit (1992) and basically involves use of land resources, including soils, water, animals and plants for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (United Nations Earth Summit, 1992). Factors such as urbanization and industrialization threaten the long term productive potential of land in peace. The situation is highly aggravated when a country is experiencing, a war situation where landmines pose a major threat to current and future land use. Landmines, or commonly referred to as mines, stand out from other forms of warfare, because of their very tenacious, undiscriminating and unrestrained nature, remaining active for decades, represent a major threat to civilians. This demands that all mines and ERW affecting areas where ordinary people live must be cleared within a specified area and to a specified depth, and safety of people in areas that have been cleared must be ensured and guaranteed.

The Secretary General of the United Nations, Ban Ki-moon, acknowledged the progress of landmine clearance in the past decade towards eradicating the threat of antipersonnel landmines and Explosive Remnants of War (ERW). Ban Ki-moon further states that in the year 2014, UN has destroyed more than 400,000 landmines and ERW and cleared more than 1,500 km of roadways (United Nations Mine Action Services, 2015).

With the dramatic fall in the number of new victims in most mine-affected countries, the primary justification for demining activities today is to support development. Suspicion that land is mine contaminated interferes with utilization of land for reestablishment of communities, economic development and recovery, poverty reduction, and international /private-sector investment. Traditionally, the systematic clearance of mines and ERW is grouped into two main categories: landmine clearance and battle area clearance which included clearing the entire suspected areas. The modern process of releasing land for beneficiaries known as land release which happens to be the main subject of this paper is an effective and efficient application of survey and clearance to remove the threat of landmines and ERW contamination which includes minimal mechanical interference.

The most meaningful measure of landmines' effects is the amount of high priority land where mines are hidden. This land could be farmed, is socially and economically valuable, or is vital to the movements of people nearby. According to Consulting (2009), the total area suspected of being mined is too large for the resources available for clearance throughout the world. The process of fully clearing all such areas is slow and expensive, and it requires many decades to complete. Most suspect land has no mines; Consulting (2009) experiences that, less than 5 percent of Suspected Hazardous Areas (SHA) prove to contain many contamination in most countries, and many clearance operations find none at all. Ahmed (2014) sets an example that in 1996, Norwegian People’s Aid (NPA Norwegian International Non-Governmental Organization active in humanitarian disarmament) cleared a village in Mozambique after it had been abandoned by the entire population of around 10,000 villagers due to alleged mine infestation. After three months of work, the deminers found four mines. Four mines had denied the people access to their homes and land and caused the dislocation of 10,000 people. Lardner (2009) shows that past efforts to improve and optimize mine clearance have revealed that clearance and survey assets are often used too conservatively, commanding significant resources to clear land with little or no actual mine contamination. There are limited demining resources available and, despite an acknowledged need, this is not likely to change. Paktian (2008) highlights that using these scarce resources in mine free areas or suspicious areas may have the potential to damage the environment in which mine clearance is conducted. This damage not only includes the short term effects caused by demolition activities, but long term effects that may be caused by removal of vegetation, excavation of soil, disruption to soil structure that maybe subject to erosion while operations may also damage the natural habitats of insects or wildlife and affected areas of historical or cultural significance. When demining operations are conducted, using various machines in support of the land release process, this involves the removal of vegetation, and sometimes breaking of the soil crust and penetration of the ground. If this occurs on ground that may be subject to erosion, this can lead to environment damage and there is also a risk of, release smoke, toxic fumes and fuel and oil leakage.

In 2006, the Geneva International Centre for Humanitarian Deming (GICHD) developed the Land Release Methodology which is adoptable to accommodate unique situations in any given country using universally applicable generic standards and principles. This will free demining resources, which are often scarce, for the clearance of genuinely mined areas. Generally, the land release will measure the extent of actual contamination and determine the appropriate tool or tools to be used to resolve the problem and release the area with high-confidence that they are indeed free from contamination. The land release approach is changing the operational and strategic approach of the demining sector as a whole. It focus more on the collection and use of improved information to more effectively apply demining assets and return more land to productive use in a more efficient and cost effective manner. In the last few years the term Value for Money (VfM) has become more and more commonly used by mine action donors. This refers to the process of getting as much impact as possible for the input provided.

The land release concept and related techniques are now being employed successfully in the demining industry as a whole (GICHD, 2014). Demining traditionally is a practical discipline mainly carried out by professionals in the shape of former military staff. Most of the work involved in the sector is practical and has historically up till now been carried out, more or less, with the same equipment and the same methods (with some technological and methodical developments), since the years following Second World War. This is also the reason why very little academic work has been carried out in the area and why there is a lack of academic publications covering the subject. There are some publications and journals that could be considered as academic in part, such as some of the GICHD, (www.gichd.org) publications and the James Madison University published Journal of Mine Action, which is still not peer review and not in full can be considered as being academic. (The above paragraph is based on a personal communication first author of this paper had with a mine action expert Pehr Lodhammar, 2015).

This paper explores the existing theoretical and empirical findings in the literature to examine the land release process in humanitarian demining, and to find out whether it promotes sustainable land management. The land release process will be described in general terms in order to familiarize the reader with principles, methods, approaches and various technologies used as an introduction. This will then be followed by a brief description of the relevant method that affects sustainable land management. The knowledge of land release methods will be of significant importance to relate to components of sustainable land management and make recommendations to increase performance in a given region. This paper also makes concrete recommendations for strengthening land release process for demining operators followed by the conclusion of the study.

Methodology

In order to maintain a tractable scope and provide a useful starting point for more in depth investigations the paper focuses primarily on research that evaluates and models the factors that influence the quality of relationship between sustainable land management and the land release process in humanitarian demining through a comprehensive literature review.

The purpose of conducting this literature review is to enable the reviewers to understand, interpret, analyze, synthesis, and develop arguments related to sustainable land management and the influence of 'land release' further.

A literature review gives some background and context to the research. The reviewers understand how the research fits into the broader picture and also how it relates to previous work. This review explores theoretical and empirical findings related to sustainable land management. It establishes a framework within which to present and analyze the findings. This review uses publications, international journal articles, edited works, and other research materials to achieve its objectives. Mine action literature is not, in general terms, well stocked with quality literature although there are a number of noteworthy exceptions. With such a short timescale for the development of theory of land release in humanitarian mine action (i.e., the 13 years of operations since the first humanitarian mine clearance in Afghanistan), and with such a diverse catalogue of countries in which programmes are operating, the studies undertaken to analyze the land release models are limited. Papers that deal primarily with sustainability, landmine detection, landmine characterization, victim assistance and stockpile destruction have been excluded. This review also assumes a rather pragmatic working definition of land release as the process of applying all reasonable effort to identify, define, and remove all presence and suspicion of mines/ERW through nontechnical survey, technical survey and/or clearance (International Mine Action Standards 7.11, 2013). Obviously there will be viable exceptions to this rule. This study highlights instances from Sri Lanka as the country is experiencing the resettlement and development stage subsequent to mine clearance activities in most affected areas in the northern region.

Literature Review

The research on land release and sustainable land management is vast and extensive. Researchers from different parts of the world and from different journals have addressed the issues related to land release and sustainable land management from different perspectives.

Over recent years, the demining community had begun to struggle with a fundamental question related to the efficiency of mine clearance efforts. That question was caused by the increasing realization that much of the land being cleared, using expensive and resource-intensive assets, did not, in the end, contain hazardous items. It has been common for general assessments and impact surveys to overstate the scale of the problem, by declaring large areas to be suspect.

It has always been a challenge to distinguish clearly between those areas of land that pose a high degree of threat to local populations, and those that may have simply fallen into disuse. In addition, over recent years, extreme pressure on land in some countries has forced local populations to take matters into their own hands in the form of village demining, or simply re-occupying land, regardless of whether the government agency classifies the area as a suspected hazardous area (SHA).

The GICHD first published a guide to land release in 2007, drawing together the experience of programmes of six mine affected countries.
The process of ‘land release’ involves a significant amount of preparatory activities before mines and ERW can be located and actually cleared. Although the cost per unit of land area for these preparations is much lower than the cost for clearance, the volume of land to be investigated in the preparatory stages is generally much larger (Kruijff et al, 2012).

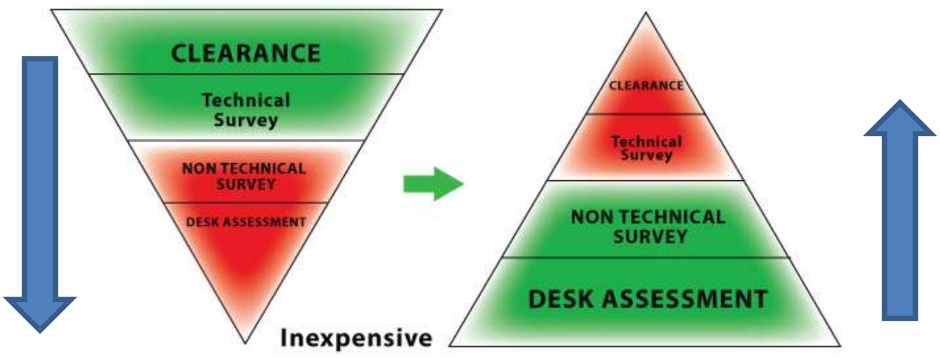
Land Release

According to International Mine Action Standards (2013) Land release is defined as “the process of applying ‘all reasonable effort’, to identify, define and remove all presence and suspicion of mines and ERW through non-technical survey (NTS), technical survey (TS) and/or clearance”.

Almost all of the effort associated with the identification of hazardous land and its subsequent cancellation, reduction and clearance processes relates to the collection, processing and analysis of information in order to support decisions about where mines/ERW are to be found (and where they are not) and where further efforts should be made. “All reasonable efforts” in mine action represent the effort that it is reasonable to expect should be applied in order to achieve the desired level of confidence that cancelled, reduced and cleared land is free of mine/ERW contamination within specified limits. Effort is ‘reasonable’ when it can be shown, on the basis of reason (or logic), that the efforts applied could be expected to have discovered evidence of contamination had it been present, and/or could be expected to have found and destroyed/removed all contamination where it was present (IMAS, 2013).

Land release is an evidence-based decision-making process that helps to determine with confidence which land needs further action and which does not. It involves the identification of hazardous areas, the cancellation of land through non-technical survey, the reduction of land through technical survey and the clearance of land with actual mine/ERW contamination.

The land release pyramid illustrates the transformation from the traditional approach of clearance (Figure 1). Many governments employ clearance by default to eradicate suspected explosive hazards. Modern land release methodology provides more efficient approach (Gray, 2014).



(a) (b)

Figure 1: Evolution of the land release pyramid traditional (a) to modern (b)

A two tier system of land classification has been promoted: hazardous areas are either suspected hazardous area (SHA) or confirmed hazardous areas (CHA) according to the availability and quality of evidence. The term "SHA" refers to an area where there is reasonable suspicion of mine/ERW contamination on the basis of indirect evidence of the presence of mines/ERW (IMAS, 2013). The term "CHA" refers to an area where the presence of mine/ERW contamination has been confirmed on the basis of direct evidence of the presence of mines/ERW (IMAS, 2013). Gray (2014) argues that this evidence based approach discourage the creation of SHAs unless credible information can justify such a decision.

Nontechnical Survey

The term Nontechnical Survey (NTS) refers to "the collection and analysis of data, without the use of technical interventions, about the presence, type, distribution and surrounding environment of mine/ERW contamination, in order to define better where mine/ERW contamination is present, and where it is not, and to support land release prioritization and decision-making processes through the provision of evidence" (IMAS, 2013).

Vital aspects of the Nontechnical land release method are the quality and relevance of essential information gathered without the use of technical interventions in a specific area. NTS is usually a first step in order to determine evidence of the presence or absence of landmines and other ERW while clearly distinguishing between mines and other unexploded ordnance (UXO).

Snail Aid Technology for Development is an Italian social enterprise researching and implementing technologies for sustainable development. A recent study undertaken by Snail Aid Technology for Development carried out a survey in 14 different mine action stakeholders in six countries to assess land release practices. Cepolina (2013) found that generally all NTS efforts were intended to:

- Identify CHA while assigning a certain level of confidence to the statement that the area contained mines or ERW.
- Re-examine the evidence for the status of SHA while assigning a level of threat or level of suspicion to the area.
- Classify CHA/SHA according to the socioeconomic impact that the hazards had on communities, thereby informing the prioritization of subsequent TS and clearance work.

Gray (2014) argues that NTS should be conducted by trained staff who can gather and critically analyze information from a broad range of stakeholders in affected communities and map hazardous areas as accurately as possible. As a guide, these maps can help plan clearance activities; however, there should be leeway to edit, update and redraw boundaries of hazardous areas when more credible information becomes available.

Matić et al., (2014), highlights the fundamentals that should be taken into account when carrying out a military-based interpretation of a SHA. They underline the fact that information gathered from available military archives should be completed with other elements such as communication networks (e.g. roads and streets), vegetation, soil properties and land use.

NTS is a great tool to collect indicators of mines and ERW absence or presence used to evaluate the probability that an area was contaminated.

National Mine Action Centre Sri Lanka (http://slnmac.gov.lk) states that it has carried out NTS to identify and to collect the essential information about a new CHA or an existing SHA, which has in some way been identified through, perhaps, an emergency survey, an impact survey, military records or word of mouth etc, in order to allow a decision to be made as to what to do next in or with that area. According to Vanhuyse *et al*., (2015), once units' positions have been located, potential mine contamination "hotspots" can be identified. This involves military knowledge relating to mine laying and to the temporal dynamics of the conflict, but also fine-scale topographic analysis, information on the land use, trafficability analysis, etc.

Before carrying out Technical Survey (figure 1), all efforts must first be made to cancel SHA through NTS. A review of Landmine Impact Survey (LIS) carried out by GICHD (2011) found out that Ethiopia, Cambodia and Bosnia and Herzegovina demonstrated that the size of SHA can be reduced on average about 90%, if subjected to NTS as defined in IMAS 08.20 and 08.21. The fact that it has been possible to cancel such vast areas reflects the exaggerated extent of previously recorded SHA captured through LIS methodology, which placed a focus on ‘impact’ at a community level, rather than the accurate delineation of hazards.

Technical Survey

Technical Survey (TS) is a detailed survey intervention with technical assets that can detect or reveal the presence of mines/ERW. In many cases however, when technical survey and clearance are completed that the true nature and extent of mine/ERW contamination can be fully understood.

As defined by IMAS (2013), “Technical Survey is the collection and analysis of data, using appropriate technical interventions, about the presence, type, distribution and surrounding environment of mine/ERW contamination, in order to define better where mine/ERW contamination is present, and where it is not, and to support land release prioritization and decision making processes through the provision of evidence”.

According to GICHD (2011), TS involves a physical intervention, using survey or clearance assets in a SHA. TS serves the following main purposes to:

- Confirm the presence, or absence, of mines/ERW, identify the type of hazards, and better defines boundaries of SHA that require clearance
- Collects information to support decision making
- Provides local people sufficient confidence to use land, without having to resort to clearance of an entire area.

  It is usually integrated into the wider survey process and Bach (2014) introduces four principal roles:
- Assist NTS in defining more accurate and thus smaller CHA polygons
- Define parts of CHAs that require clearance
- Investigate buffer zones around cleared areas
- Release land within CHA polygons

The real sources of information in TS are the mines in the ground and defined locations. TS helps determine the likelihood of mines being laid, the type of potential patterns and the number of mines typically found in similar conditions. Bach (2014) states that targeted TS integrated with the initial NTS permits recording of smaller and more accurate CHAs. Inside a CHA the basic principle is to search the area until mines/ERW are located, which is where full clearance starts and proceeds to the front and sides, following the mine patterns if they exist. If no mines are found, sufficient TS must be applied to establish high enough confidence that the area is free from contamination.

According to Sri Lanka National Mine Action Standards (2010) Technical survey is usually undertaken using the same assets as clearance but with a different methodology. Virtually any demining asset can be used as long as it has been established that the asset can provide reliable and useful information, with a defined degree of confidence, in relation to the hazards that are expected to be found.

Clearance

The most familiar and visible part of land release is the clearance of mines and ERW. According to GICHD (2014) clearance refers to an intrusive information-gathering and threat removal process that fully defines a hazardous area whilst removing explosive hazards. The aim of clearance is to create safe land by locating and then destroying all mines and other explosive hazards within a defined area to a specified depth. This requires management systems and clearance procedures that are appropriate and effective, safe and efficient.

Clearance is typically composed of three elements: manual clearance, mechanical clearance and animal detection systems. The decision to select relevant combination of techniques in a country setting is influenced by the extent and type of threat which the ERW pose, as well as other important factors such as financing and security, infrastructure terrain and national laws.
Figure 2 summarizes the components of the land release process. (after Gray, 2014).

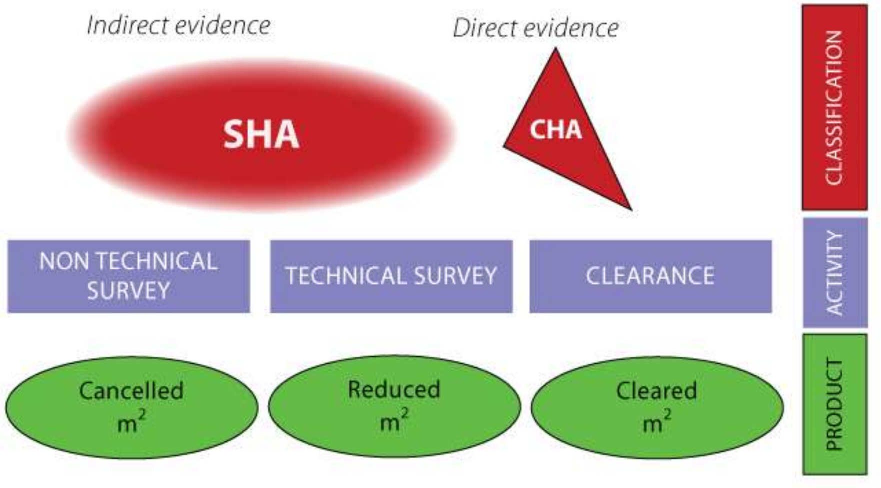


Figure 2: Components of Land Release process

Manual Clearance
Manual mine clearance methods have not changed significantly since World War II. Techniques involve in deminer working along a marked lane using a metal detector, rake, prodder, or an excavation kit until a suspicious object is encountered. Although these methods often mean relatively slow progress, they are widespread and popular in mine action programmes, in recognition of the very high levels of confidence associated with the land they release. Some organizations involved in

manual clearance choose not to use alternative methods and assets. (GICHD, 2014)

Manual deminers are used to create and clear lanes and grid systems, performing targeted and systematic investigations as well as area clearance. Deminers are usually placed at a defined safety distance from each other, continuing clearance drills until discovering a suspicious object. The deminer then carefully excavates around the object and, if it appears to be a mine or an item of explosive ordnance, it is either blown up in situ or defused and moved for destruction at the end of day. In countries where labour costs are low, manual deminers can be cost-effective. Thick vegetation, rubble, debris, and urban areas are all factors that slow down manual clearance, prompting consideration of alternative means. Conversely, manual deminers can assist mechanical ground processing and clearance systems greatly in places with obstacles restricting machine access, and are used for community liaison tasks. (GICHD, 2014)

Mechanical Clearance

A variety of mechanical systems to detonate or destroy mines are available. They are known to be highly cost-effective components in a demining programme, accelerating the progress of other assets, through removing vegetation, earth bunds, tripwires and levelling up ground. The machines are utilized in technical survey and, sometimes, can be used as a primary clearance method. The most common types of machines used in demining operations are equipped with flails, tillers and rollers.

Today a multitude of demining machines, equipped with reliable power trains, remote controls, navigation and positioning systems, and comprehensive service and support packages. In some cases agricultural and construction vehicles have been converted and armoured for mine clearance, offering savings for investment in terms of the availability and low cost for spare parts. For example, in Sri Lanka heavy D8 Caterpillar machines are used by fitting external heavy roller attachments. The JCB vegetation cutter was deployed predominantly in support of the demining teams in areas where vegetation growth was extensive and presented a significant barrier to the manual clearance teams. (Swiss Foundation for Mine Action, 2009)

Mechanical systems perform technical surveys, determine the boundaries of SHA, and play an important role in the overall land release process. The level of confidence in their use for clearance has increased, under the right circumstances as it has a risk reduction tool complementing the manual clearance methodology and animal detection system.

In 2004, a study undertaken by GICHD of mechanical mine clearance equipment, examining factors influencing their efficiency, productivity and cost-effectiveness concluded that in suitable conditions (threat type, soil and topography) machines can be used as a primary clearance system. A decade later, confidence has increased and some mine action programmes use machines as a primary clearance system.

According to the Ministry of Economic Development (2010) in Sri Lanka, flail machines are also used for the reduction of risk in areas where sporadic mine lying took place - typically by the LTTE. Here the flail machines work in a grid pattern to try and identify areas of sporadic demining in large areas of low threat land - such as paddy fields thereby releasing up to 1,500 m^2 per day of high priority farm land for agricultural development.

According to GICHD (2014) there are some mechanical systems developed for simultaneous purposes. For example, if a ground engaging tool is used as a flail during demining operations it may destroy mines, remove vegetation and loosen soil. If its prime mover is also fitted with a magnet it can remove metal debris and collect information on mine and ERW contamination.

GICHD (2014) highlights the fact that considering whether to deploy machines into an area is their impact on information and the extent to which decisions on when to stop technical work can be taken. In some cases, more cautious use of machines may be appropriate to preserve patterns of contamination. Balance between the use of a machine as a technical survey tool and as a clearance asset depends not just on the level of confidence associated with its clearance capabilities, but also on its ability to preserve and deliver, or disrupt and degrade, information.

Animal Detection System

The animal most commonly used for mine detection is the dog, owing to its proven ability to work with and be trained by humans. Rats are also used. They are trained to detect odors from specific vapors associated with the explosive or other components of mines and munitions. This is referred to as an animal detector system (GICHD, 2014).

Dogs have been used for sensing and tracking for centuries and in demining since World War II. The animal indicates the presence of a mine to its handler. It is then the deminer's responsibility for investigation of the indication provided. Regardless of the limitations of animals like any other demining asset, with good training, planning and practice many of the weather and environmental limitations can be overcome.

As stated by GICHD (2014), explosive detection animals can detect mines with a low metal content, deep buried AT mines and mines buried in areas with a high metal contamination where the use of metal detectors would be difficult. They can be faster and more cost-effective than manual demining detector methods as they can be sent to areas inaccessible for machines. Animals can be used with advantage in technical survey roles. Daily progress has been recorded from 300 m2 to 2,000 m2, depending on environmental conditions, the type of task and the operational concept in use. Animal detection system are at their best when indicating individual mines or minefield boundaries, rather than trying to work within dense concentrations of mines.

Sustainable Land Management

A definition developed by the World Bank (2006) identifies Sustainable Land Management (SLM) as "a knowledge-based procedure that helps to integrate land, water, biodiversity and environmental management to meet rising food and fiber demands while sustaining ecosystem services and livelihoods". Smyth and Dumanski (1993) defined SLM as a combination of technologies, policies and activities aimed at integrating socioeconomic principles with environmental concerns in order to maintain and enhance productivity, reduce the level of production risk, and enhance soil's capacity to buffer against degradation processes, protect the potential of natural resources and prevent degradation of soil and water quality, be economically viable, be socially acceptable, and assure community access to the benefits from improved land management. SLM comprehends other established approaches such as sustainable land use, water conservation, conservation agriculture, natural resources management, food production and integrated biodiversity management. SLM provides local solutions to challenges exacerbated by global change (such as food security, disaster risk reduction, and desertification control and poverty alleviation). It endorses incorporation of social, economic, physical and biological needs and values, to achieve a more holistic, productive and healthy living. Lately, SLM has emerged as a more formal, generalized concept that covers the dynamics of soil, vegetation and entire socio-economic systems. Motavelli *et al.* (2013) suggests components of SLM as (1) understanding the ecology of land use management, (2) maintain or enhance productivity, (3) maintenance of soil quality (4) increased diversity for higher stability and resilience (5) provision of economic and ecosystem service benefits for communities, and (6) social acceptability.

Landmine impact on Sustainable Land Management

Landmines cause multifaceted and interconnected ecological and socio-politico-economic problems. According to Ahmed (2014), the impacts of landmines on soil, flora and fauna, and people are felt at different levels of the ecological system, whether the mines have detonated or not.

The fragility of the natural environment is threatened by landmines due to change of the quality of land, and through abuse of biotic resources and habitat destruction. Landmines pose a lose-lose situation because they will cause land degradation regardless of landmines being left in the ground or exploded. A study undertaken by Rapillard & Walton (2014) states that antivehicle mines contamination hampers agricultural development in South Sudan. In Easten Equatoria, antivehicle mines hampered the development of tea plantations and impeded expansion of the timber sector. In addition, former sugarcane plantation were not put back to use due to contamination from antipersonnel and antivehicle mines.

The major impact of landmines is to block access to land and its resources and subject people life to a continuous danger. Besides this, the social, medical, economic, and environmental consequences are immense (Blagden, 1993; King, 1997; Habib, 2002b). A study undertaken by Berhe (2006) pointed out that the most prominent ecological issue associated with landmines presence (or fear of) is access denial to vital resources. The fear of presence of even a single landmine can deny people access to land that they desperately need for farming, water supply and other basic needs. Andersson, Palha da Sousa, & Paredes (1995) states that landmines also obstacles food security by making land unavailable for growing food and herding livestock.

Biodiversity is threaten by landmines in a given region by destroying vegetation and plants during explosions, and when animals fall victim. Troll (2000) shows that landmines pose burden for threatened and endangered species. Landmines have been caused for various species to the brink of extinction. Moreover, landmines are used for rustling scarce species of wildlife (Nacho´n, 2000), and internally displaced people further contribute to loss of biodiversity when they hunt animals for food or destroy their habitat in order to make temporary shelters for themselves (Troll, 2000).

Landmines impact on plants by posing slow death of trees when they contain shrapnel injuries or scrapes of their bark or roots when fragmentation mines detonate, providing an entry site for wood-rotting fungi (Troll, 2000). In regions where farming and other livelihood areas contaminated by landmines, forests become the last resort for food, fuel wood and shelter. In response, mine affected population destroys valuable forest products, including fruits and timber, to start new livelihood somewhere else. Moreover, wood used as firewood becomes unsafe and troublesome when metal fragments are embedded in it (Westing, 1996). Landmine detonation causes damage to the soils' stability by shattering the soil structure, and causing local compaction, and increasing the susceptibility of soil to erosion (Berhe, 2006). Landmines interfere with the ability of the soil system to serve as a geochemical sink for contaminants. Depending on density of mines per unit area; the type and composition of the mine; and the length, landmines promotes pollution by accumulation of non-biodegradable toxic waste such as depleted uranium (Gray, 1997).

Many of the long lasting organic and inorganic substances derived from landmines can be delivered directly or indirectly into soil, plants, water and food products. These pollutant compounds can filter into subterranean waters and bioaccumulate in the organs of animals, fish and plants. Their effects can be mortal to animals as a nerve poison to hamper growth (Organization of American States, 1999). A significant landmine related chemical contamination threat is lead toxicity which results humans in kidney damage and birth defects and high levels of mercury can result in neurological disorder (Agency for Toxic Substances and Disease Registry, 1999). Limited/or no access for land, soil contamination, combined with loss of biodiversity add up to land degradation—reduction in productivity of previously productive land (Food and Agriculture Organization, 1997). Landmine and war effects are similarly experienced, unfavourable climatic and economic conditions, and governments' uncertain commitment to the environment (Eden, 1996 and Stone, 1998).

Contribution of Land Release process for Sustainable Land Management

Land Release in Mine Action is the process whereby the demining community identifies, surveys and prioritizes suspected hazardous areas for more detailed investigation, which eventually results in the clearance of landmines and other explosives, thereby releasing land to the local population (Kruijff et al. 2011).

At the global level, a large area of previously productive land has been rendered unproductive due to landmines and traditional landmine clearance which adds to the extent of land degradation and desertification described in the international literature. However, there is a general consensus that it is way too practical to prevent land degradation via the application of good management of land release process, in mine affected regions. In comparison to conventional demining, land release process makes all the reasonable effort to minimize unsafe land for agriculture, land degradation and water scarcity. It also harbours positively to fundamental ecosystem services such as regulating water cycles, gas emissions, and helping to preserve biodiversity.

As a result of 30-year civil war in Sri Lanka an estimated area of 2,064 km^2 was contaminated by landmines and ERW. During the 6 year period aftermath of the war, Sri Lanka Army and other international demining agencies in Sri Lanka were successful in releasing approximately 96% of contaminated land, then only 78.7 km^2 remaining for survey and clearance. It is important to realize the efficiency of completing this task is a direct result of the Land Release methodology rather than the traditional mine clearance supposedly. Conservative estimate shows that the traditional method would have taken at least more than ten times the time taken by Land Release methodology. Another important factor is that of the land released so far a good 50% of them have not subjected to any type of technical interventions. Regional Mine Action Office Sri Lanka (2015) reports approximately 1,089 km^2 large area has been released through NTS including cropland, irrigated land and rangeland in Northern Sri Lanka since the commencement of mine clearance activities. This land which has not been bombarded remains in the former productive condition for restart agriculture. These areas have not been subjected for burning and ground preparation, therefore, the areas were still in productive condition. This implies a large amount of land has been released through nontechnical survey is an evidence-based approach which proves to be an efficient system to release land without excavating or harming the ground. These provinces demonstrate poverty rates higher than the national average among populations that are predominantly reliant upon agricultural and farming activities for income; every square metre of land is precious.

Technical survey concept follows the logical framework of NTS and complements the decision-making process to release land by measuring degrees of confidence in areas being mine free (Bach, 2011). TS is a slow and vigilant approach which helps to locate mine laid patterns using extreme caution to avoid causing any damage to the site. The TS always resemble environmental practices such as careful survey, marking and removal of items with only minimal disturbance to surroundings. Instead of destroying the mines *in situ,* the found mines has to be disarmed and transported to another location for destruction. TS not only aided in restoring and safeguarding these sites-thereby protecting civilians and facilitating sustainable land management- but it also plays a key role in the wider environmental recovery and preservation efforts. The Northern Sri Lanka is a unique environment. Northern Provincial Council (2009) states that landscape offer a rich fertile for paddy cultivation in “Ricebowl” area which is over 7,000 acres in Mannar district. Additionally the area is home to large population of birds, seals and reptile species. Mine clearance would inevitably have caused impacts on some of the endangered species within the Northern Province. Therefore, it was crucial to conduct TS in order to mitigate the impact clearance activities would have on the environment. The environmental mitigation measures made by TS mainly focused on protecting wildlife, minimizing erosion and reestablishing the area including removal of waste generated from the clearance work.

Therefore, clearance was carried out under strict guidelines of IMAS which address concerns relating to the aforementioned mitigation measures.

Machines are used due to heavy contamination and speed up TS and clearance operations so that land can be released to the beneficiaries which open new economic prospects. According to Habib (2008), the aim of using machines is typically not to clear land from mines, but to prepare ground for post-machine full clearance. Subsequent to mechanical clearance, deminers ensure the safety of land with the use of metal detectors. Because of the buried artifacts and the presence of metal articles in the soil, the manual clearance progress slowly but yielded success in clearing the farming areas while preserving the current conditions of the sites. Clearance removes the chemical composition of explosives off the soil and water resources. Also Sargisson *et al.* (2012) points out that the use of dogs and rats may offer advantages over other methods of detection in these situations due to their ability to cover large land areas more quickly than other detection methods, while minimizing damage to fragile ecosystems.

However, with careful planning and coordination, land release process may be uniquely positioned to help post conflict countries maintain their land without significant deviation from or original productive conditions.

Results and Discussion

Quality land release process is essential for sustainable land management because landmines and ERW hinder the development process, leads to loss of biodiversity, soil contamination and threat to survival by denying access to the resources. They pose grave threat to sustainable land management and thereby to future generation. Hence, it is evident that there can be no blueprint for sustainable land management in mine affected countries. Land Release is a vital prerequisite to SLM in mine affected regions. The LR process enables pragmatic decision-making to better target clearance assets to minimize residual risk and promote sustainability.

It is important to integrate mine/explosive risk education (MRE) as a key role in land release process so that it helps mitigate the fear of residents whose lands have been demined. MRE refers to all educational activities seeking to reduce mines and ERW injuries by raising awareness and promoting behavioural change among at-risk groups. The objective MRE is to provide sufficient information to recognize and report these items to the appropriate authorities. The authorities can then remove the items, making the areas safe for people and creating an environment where economic and social development can occur free from the constraints imposed by contamination. Currently, MRE is carried out as a standalone project in most mine affected countries. Integrating MRE into land release process strengthens security and safety of people who live in close proximity to mine fields as they might come across landmines/ERW. MRE programmes raise awareness of the inherent potentials and constraints of lands and educate people to report about suspicious objects to authorities and get them removed and safely continue livelihood activities which results SLM. People will learn that landmines not only stand a threat to their lives but change the natural environment in so many ways and make it hard, for societies to achieve sustainable land management that they might otherwise have attained.

Researchers from Virgina Commonwealth University are investigating how plants can be used to detect buried explosives, such as landmines in densed vegetation, where demining methods are difficult. This is an example which illustrates importance of focusing on interdisciplinary approaches on demining which promotes sustainable land management.

References

a) *Agency for Toxic Substances and Disease Registry (ATSDR). (1999) Toxicological Profile for Mercury. US Department of Health and Human Services. Public Health Service: Atlanta, GA.*

b) *Ahmed, I. (2014) Landmines: A Threat to Sustainable Land Management. IOSR Journal of Humanities and Social Science. 19 (3). (4/March). pp. 01-08.*

c) *Andersson, N., Palha da Sousa, C., & Paredes, S. (1995) Social cost of land mines in four countries: Afghanistan, Bosnia, Cambodia, and Mozambique. British Medical Journal. 311. pp. 718–721.*

d) *Bach, H. (2014) Scalable Technical Survey for Improved Land Release Rates. Journal of ERW and Mine Action. 18 (1). Available from James Madison University. pp. 17-21.*

e) Bach, H. (2011) Thailand and Compliance with the APMBC, Journal of ERW and Mine Action. 15 (3). Available from James Madison University. pp. 51-57.
f) Berhe, A.A. (2006) The Contribution of Landmines to Land Degradation. Land Degradation and Development.18. pp. 01-15. Available from: www.interscience.wiley.com. Accessed: [04.06.2015]
g) Blagden, P. M. (1993) Summary of UN Demining. Proceedings of the International Symposium on Anti-Personnel Mines. Montreux. April 1993. CICR/ICRC. pp 117-123.
h) Cepolina, E. (2013) Land Release in Action. Journal of ERW and Mine Action. 17 (2). Available from James Madison University. pp. 44-50.
i) Consulting, D. (2009) Survey and Land Release: Lessons from Recent Country Experience. Journal of ERW and Mine Action. 13 (2). Available from James Madison University. pp. 46-50.
j) Eden, M. (1996) Land degradation: environmental, social and policy issues. In Land Degradation in the Tropics: environmental and policy issues, Parry JT (ed.). Pinter: London.
k) Food and Agriculture Organization. (1997) Production Yearbook. 48. Food and Agriculture Organization. Rome.
l) Food and Agriculture Organization of the United Nations. (1993) FESLM: An international framework for evaluating sustainable land management. World Soil Resources Report. pp. 1-85.
m) Geneva International Centre for Humanitarian Demining. (2011) A Guide to Land Release: Technical Methods. Second edition. Geneva. GICHD.
n) Geneva International Centre for Humanitarian Demining. (2008) A Guide to Land Release: Non-Technical Methods. Geneva. GICHD.
o) Geneva International Centre for Humanitarian Demining. (2014) A Guide to Mine Action. Fifth Edition. Geneva. GICHD.
p) Gray, H. (2014) Amendments to the IMAS Land Release Series. Journal of ERW and Mine Action. 18 (1). Available from James Madison University. pp. 11-13.
q) Gray, B. (1997) Landmines: the most toxic and widespread pollution facing mankind. A Colloquium, Towards Ottawa and Beyond—Demining the Region: The Environmental Impacts. Sydney, Monday 14th to Thursday 17th July 1997. University of Sydney. International Campaign to Ban Landmines.
r) Habib, M. (2008) Humanitarian Demining: the Problem, Difficulties, Priorities, Demining Technology and the Challenge for Robotics. Humanitarian Demining: Innovative Solutions and the Challenges of Technology. February 2008. I-Tech Education and Publishing. Vienna. pp. 392.
s) International Mine Action Standards. (2013) Technical Survey, 8.2. United Nations Mine Action Service. USA.

t) *King, C. (1997) Mine Clearance in the Real World. Proceedings of the International Workshop on Sustainable Humanitarian Demining. Zagreb. SusDem'97.*
u) *Kruijff, M., Eriksson, D., Bouvet, T., Griffiths, A., Craig, W., Sahli, H., González-Rosón, F., Willekens, P., and Ginati, A. (2011) Space Assets for Demining Assistance. Conference Paper in ACTA Astronautica. Available from: ResearchGate [16.08.2012]*
v) *Lardner, T. (2009) The GICHD Land Release Project. Journal of ERW and Mine Action. 12 (2). Available from James Madison University.*
w) *Matić, Č., Laura, D., Tursić, R., Krtalić, A. (2014) Analytical assessment for the process of collecting additional data on a suspected hazardous area in humanitarian demining. CROMAC-CTDT Ltd., Zagreb.*
x) *Ministry of Economic Development. (2010) The National Strategy for Mine Action in Sri Lanka. September. Available from National Mine Action Centre. Colombo. pp. 27.*
y) *National Mine Action Centre Sri Lanka. (2012) Manual Mine Clearance. Available from http://slnmac.gov.lk/manual-mine-clearance Accessed: [29.06.2015]*
z) *Nacho´n, C. (2000) Environmental Aspects of the International Crisis of Antipersonnel Landmines and the Implementation of the 1997 Mine Ban Treaty: Thematic Report. Landmine Monitor Report 2000. International Campaign to Ban Landmines. NY.*
aa) *Northern Provincial Council. (2009) Plough ceremony held at Rice bowl area in Mannar. Government of Sri Lanka. Available from http://np.gov.lk/index.php?option=com_content&view=article&id=252 Accessed: [06.07.2015]*
bb) *Organization of American States. (1999) Informe—Impactos Socioambiontales De Las Minas Antipersonnel En La Cordillera Del Condor. Washington DC.*
cc) *Regional Mine Action Office. (2015) Demining progress report. Available from Regional Mine Action Office. Kilinochchi. Sri Lanka.*
dd) *Sargisson, R.J., McLean, I.G., & Brown, J. (2012) Environmental Determinants of Landmine Detection by Dogs: Findings from a Large-Scale study in Afghanistan. Journal of ERW and Mine Action. 16 (2). Available from James Madison University. pp. 46-50.*
ee) *Paktian, F. (2008) Mine Action and the Environment. Journal of ERW and Mine Action. 11 (2) Available from James Madison University.*
ff) *Sargisson, R.J., McLean, I.G., & Brown, J. (2012) Environmental Determinants of Landmine Detection by Dogs: Findings from a Large-Scale study in Afghanistan. Journal of ERW and Mine Action. 16 (2). Available from James Madison University. pp. 46-50.*

gg) Smyth, A & Dumanski, J. (1993) FESLM: An international framework for evaluating sustainable land management. World Soil Resources Report. Food and Agriculture Organization of the United Nations. Rome.

hh) Sri Lanka National Mine Action Standards. (2010) National Steering Committee for Mine Action, Second Edition. SLNMAS 4.10. Sri Lanka.

ii) Stone, C. (1998) The Environment in War Time: An Overview. International Law Institute. The First International Conference on Addressing Environmental Consequences of War, Wednesday 10th to Friday 12th June 1998. Washington DC.

jj) Swiss Foundation for Mine Action. (2009) 'Caterpillar D8 Heavy Roller Machine to Speed up the Demining in the North of Sri Lanka'. Available from FSD website http://fsd.ch/news/caterpillar-d8-heavy-roller-machine-to-speed-up-the-demining-in-the-north-of-sri-lanka Accessed: [07.01.2015]

kk) Troll, K. (2000) The Impact of Anti-Personnel Landmines on the Environment. United Nations Institute for Disarmament Research: Geneva. United Nations Department of Humanitarian Affairs 1995. Landmines: From Words to Action. DHA Issues on Focus Series: No. 3:4. Geneva, United Nations Department of Humanitarian Affairs.

ll) Westing, A. (1996) Explosive remnants of war in the human environment. Environmental Conservation. 23. pp. 283–285.

mm) World Bank. (2006) Sustainable Land Management: Challenges, opportunities, and trade-offs. The International Bank for Reconstruction and Development/ The World Bank. Washington, DC.